

METAL SHEET PILE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This nonprovisional application claims priority under 35 U.S.C. § 119(a) on Patent Application No. 2002-331760, filed in Japan on November 15, 2002; the entirety of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the invention:

[0002] The present invention relates to a metal sheet pile used for earth-retaining structures, fundamental structures, bank protection structures or water cut-off walls in the civil engineering and construction fields. In particular, the present invention relates to a rolled steel sheet pile, which has a strong joint, enables high productivity, and avoids the occurrence of bending and/or warping. In addition, the metal sheet pile of the present invention provides the choice of interlocking in a plurality of ways by using a single kind of metal sheet pile.

2. Description of Related Art:

[0003] There are two kinds of steel sheet piles, one of which is manufactured by cold-pressing a steel sheet. The other kind of steel sheet pile is referred to as rolled sheet pile, and is made by hot-rolling a slab. The rolled steel sheet pile is generally more than

6mm in thickness, and is used for earth-retaining structures, fundamental structures, bank protection structures and water cut-off walls, where cross-sectional rigidity, mechanical strength and interlocking strength of the joint is required.

[0004] The rolled steel sheet pile according to the background art is usually classified into sheet pile types such as U-shaped steel sheet pile, Z-shaped steel sheet pile, hat-shaped sheet pile and straight web-type steel sheet pile. Hat-shaped sheet pile has an approximate shape similar to a U-shape, and has an end flange portion with a joint formed at an edge thereof. The end flange portion is parallel to a central flange portion of the hat-shaped sheet pile. The joints of steel sheet pile according to the background art are shaped, for example, as shown in Figure 7(a), Figure 7(b) and Figure 7(c). A joint 10 shown in Figure 7(a) is one of the most popular types of joint used for U-shaped steel sheet pile, because the joint is made by a relatively less amount of steel.

[0005] A joint 11 shown in Figure 7(b) is typically employed for straight web-type steel sheet pile, which is used for cell-type structures, because the joint has a high strength. However, the joint of Figure 7(b) is heavy and is inefficient with regard to steel consumption, since made of a relatively higher amount of steel.

[0006] A joint 12 shown in Figure 7(c) is typically used for Z-shaped steel sheet pile or hat-shaped steel sheet pile, because one side of the joint portion can be flattened. However, the joint on each side of the sheet pile is asymmetric.

[0007] A rolled steel sheet pile is normally manufactured by rolling a rectangular solid slab. When the joints to be formed at both the right and left sides are different in shape and weight, the manufacturing is difficult and bending and/or warping can occur. Therefore the joint shown in Figure 7 (c) is inefficient in productivity.

[0008] Since a rolled steel sheet pile is typically used for earth-retaining structures, fundamental structures, bank protection structures and water cut-off walls in civil engineering and construction, the joint is required to be of high strength.

[0009] In the actual use of a steel sheet pile where one joint is fitted into a joint of another adjacent sheet pile, each joint is stressed because the adjacent sheet piles are forced away from each other. In view of this, the joint of a steel sheet pile is required to be strong enough to resist such a stressful force. The strength of each part of the joint is defined by a moment arm, which is calculated by multiplying a predetermined load by a distance from the respective part to a point of a load vector, and a thickness of the respective part. Since each joint shown in Figure 7(a), Figure 7(b) and Figure 7(c) has a relatively long distance from the respective part, which is a point of stress concentration, to the point of the load vector, the strength of the joint must be increased by increasing the amount of steel used. In other words, the ratio of the strength to the amount of steel used must be increased substantially.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to provide a metal sheet pile where the above mentioned problems are overcome. Specifically, an object of the present invention is to provide a metal sheet pile having a joint with a high strength, and which is easy to manufacture, is capable of avoiding bending and/or warping during manufacturing and is capable of being interlocked in a plurality of ways using a single kind of sheet pile.

[0011] In order to accomplish this object, a rolled steel sheet pile of the present invention comprises end flanges formed at opposite ends of the rolled steel sheet pile; and joints formed at edges of each of the end flanges, wherein cross-sections of a pair of the joints at opposite ends thereof have the same shape or are line-symmetric, and the end flange and

the joint are disposed so that a center of a point-symmetry of a pair of interfitted joints is located on or near a centerline of the end flange in a thickness direction.

[0012] When one joint of one sheet pile is interfitted with another joint of another sheet pile to interlock one sheet pile with another, the pair of joints is defined as a pair of interfitted joints or interlocked joints.

[0013] In addition, the joint has a protrusion for preventing rotation near the border between the joint and the end flange. A hat-shaped steel sheet pile or a Z-shaped steel sheet pile is preferably used as a steel sheet pile of the present invention. In the case of using a hat-shaped steel sheet pile, fitting grooves on opposite ends of the steel sheet pile for receiving an engaging portion of the joint of an adjacent sheet pile open in opposite directions so that the cross-section of the two joints are point symmetric. Contrary to this, in the case of using a Z-shaped steel sheet pile, the joints on opposite ends of the steel sheet pile are arranged so that the fitting grooves open in the same direction.

[0014] The joint for interlocking includes three portions, i.e., a connecting portion, a bottom portion and an engaging edge portion in the rolled steel sheet pile of the present invention. The three portions form a fitting groove with an approximately trapezoidal and tapered-off cross-section so that a steel sheet pile is interlocked with an adjacent steel sheet pile by fitting the engaging edge portion of one sheet pile into the fitting groove of another sheet pile. In other words, a pair of interfitted or interlocked joints is formed.

[0015] The rolled steel sheet pile of the present invention is easier to manufacture, since the joints formed at opposite ends of the steel sheet pile have the same cross-section or are line-symmetric. In the case of using a hat-shaped steel sheet pile, the fitting grooves of the joints on the opposite ends of the steel sheet pile open in opposite directions so that the cross-section of the joints are point-symmetric and in the case of using a Z-shaped steel sheet

pile, the joints on opposite ends of the steel sheet pile are arranged so that the fitting grooves open in the same direction.

[0016] The above arrangements can increase the degree of freedom in selecting a combination of steel sheet piles, which enables a steel sheet pile wall to be built having various cross-sectional performance.

[0017] As mentioned above, the joint strength of steel sheet pile is defined by a moment arm, which is calculated by multiplying a predetermined load by a distance from each part of the joint to a point of a load vector, and a thickness of the respective part.

[0018] In the rolled steel sheet pile of the present invention, the end flange and the joint are disposed so that a center of a point of symmetry of a pair of interfitted joints is located on or near the centerline of the end flange in the thickness direction. This configuration minimizes the distance from each part of the joint, where a bending moment/stress is concentrated, to a point of a load vector. This provides a high strength to the joint and therefore decreases an amount of steel that must be used to manufacture the joint.

[0019] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

[0021] Figure 1(a) is a plan view of a first embodiment of the present invention, which illustrates two hat-shaped steel sheet piles interlocked with each other by a joint;

[0022] Figure 1(b) is an enlarged view of the joint of Figure 1(a);

[0023] Figures 2(a) and 2(b) illustrate examples of the cross-section of steel sheet pile walls made by a combination of the hat-shaped rolled steel sheet piles of the first embodiment of the present invention;

[0024] Figure 3(a) is a plan view of a second embodiment of the present invention, which illustrates two Z-shaped rolled steel sheet piles interlocked with each other by a joint;

[0025] Figure 3(b) is an enlarged view of the joint of the rolled steel sheet pile of Figure 3(a);

[0026] Figures 4(a), 4(b) and 4(c) illustrate examples of the cross-section of a steel sheet pile wall made by a combination of the Z-shaped rolled steel sheet piles of the second embodiment of the present invention;

[0027] Figures 5(a), 5(b) and 5(c) illustrate examples of joints of a rolled steel sheet pile of the present invention;

[0028] Figures 6(a), 6(b), 6(c) and 6(d) are explanatory views illustrating how a moment arm can be decreased to increase the strength of a joint of the steel sheet piles of the present invention; and

[0029] Figures 7(a), 7(b) and 7(c) illustrate examples of joints of steel sheet pile according to the background art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] Figure 1(a) is a plan view of a first embodiment of the present invention, which illustrates two hat-shaped steel sheet piles interlocked with each other by a joint. Figure 1(b) is an enlarged view of the joint of Figure 1(a) where a joint of one rolled steel sheet pile is fitted into a joint of an adjacent rolled steel sheet pile to form an interfitted or interlocked joint.

[0031] A rolled steel sheet pile 1 of the first embodiment has a hat-shaped cross section. The rolled steel sheet pile 1 includes a central flange 2, an end flange 3 and a web 4. The end flange 3 is generally parallel to the central flange 2. One end of a web 4 is connected to and extends from the central flange 2 at each opposite side end of the central flange 2. Each of the webs 4 is connected at an opposite end thereof to an end flange 3. A cross-section of the hat-shaped rolled steel sheet pile 1 is line-symmetric with respect to a central line perpendicular to the central flange at the center thereof except for the joints. Joints 5 are formed at ends of the end flanges 3 opposite to the webs 4. A right joint 5 and a left joint 5 have the same cross-section. However, fitting grooves of each of the right and left joints 5, 5, which receive a joint of an adjacent steel sheet pile, open in opposite directions so that the cross-section of the two joints is point-symmetric. A fitting groove 5d of one steel sheet pile 1 receives an engaging edge portion 5c of an adjacent steel sheet pile 1. At the same time, a fitting groove 5d of the adjacent steel sheet pile 1 is also fitted into by an engaging edge portion 5c of the one steel sheet pile 1. In view of this, adjacent steel sheet piles 1 are interlocked one after another so as to make a wall of steel sheet piles 1.

[0032] As shown in Figure 1(b), each of the right or left joints 5 of the first embodiment of the present invention comprise a connecting portion 5a, a bottom portion 5b and an engaging edge portion 5c which form an approximately trapezoidal and tapered-off

fitting groove 5d in cross-section. A protrusion 5e is formed on the fitting groove side of the connecting portion 5a, which prevents the joint 5 from rotation.

[0033] The above-mentioned rolled steel sheet pile 1 has two joints 5, 5 having the same cross-section located at both side ends thereof. Such a configuration enables a very stable manufacturing of the sheet pile, since the steel sheet being rolled can keep its symmetric shape in the width direction, until the terminal stage of the rolling process where the joint is to be formed by bending. This prevents the occurrence of bending and/or warping of the steel sheet.

[0034] As shown in Figure 1(b), a pair of interfitted or interlocked joints is point-symmetric about a center of point-symmetry 26, which is positioned on or near the centerline 20 of the end flanges 3 in the thickness direction. This configuration is for minimizing the distance from each part of the joint 5 where a bending moment arm/stress is concentrated to a point of a load vector, so as to give a high strength to the joint 5.

[0035] Figures 2(a) and 2(b) illustrate examples of the cross-section of a steel sheet pile wall made by a combination of the hat-shaped rolled steel sheet piles 1 of the first embodiment. The rolled steel sheet pile 1 has a pair of joints which are configured to be point-symmetric. Accordingly, it is possible to construct a steel sheet pile wall 6, as illustrated in Figure 2(b), where the sheet piles are combined so as to be turned over alternatively. In addition, it is possible to construct a steel sheet pile wall 6, as illustrated in Figure 2(a), where all the sheet piles are facing in the same direction. The steel sheet pile wall 6 illustrated in Figure 2(b) has a better cross-sectional rigidity than that of the wall shown in Figure 2(a), but requires a wider width to be built. Since two ways of interlocking the sheet piles 1 to form the steel sheet pile wall 6 is possible, a wall can be designed with various cross-sectional performance to meet the needs of a particular situation. It should

also be noted that the steel sheet pile 1 of the present invention could also be interlocked with a combination of the arrangement illustrated in Figure 2(a) and the arrangement illustrated in Figure 2(b), depending on a particular application.

[0036] U-shaped steel sheet pile and hat-shaped steel sheet pile according to the background art do not have a pair of joints which is formed by the same two joints disposed in point-symmetry. This leads to only one way of combining steel sheet piles, where all of the sheet piles face in the same direction. Therefore a conventional type of steel sheet pile product provides only one wall cross-sectional performance. The rolled steel sheet pile 1 of the present invention can offer a steel sheet pile which enables a steel sheet pile wall 6 to be constructed with various wall cross-sectional performance without changing the type of steel sheet pile being used. For example, in the steel sheet pile wall 6 shown in Figure 2(b), where the sheet piles are turned over alternatively, a better wall cross-section rigidity can be obtained ranging from up to 2.5 times that of a wall shown in Figure 2(a). However, this arrangement may be limited by the conditions where the construction is occurring.

[0037] Figure 3(a) is a plan view of a second embodiment of the present invention, which illustrates two Z-shaped rolled steel sheet piles interlocked with each other by a joint. Figure 3(b) is an enlarged view of the joint of Figure 3(a) where one joint is fitted into a joint of an adjacent rolled steel sheet pile. The joint shown in Figure 3(b) of the second embodiment is the same as the joint shown in Figure 1(b) of the first embodiment.

[0038] A Z-shaped rolled steel sheet pile 1a of the second embodiment includes a web 4, two end flanges 3, 3 connected to and extending from opposite ends of the web 4, and right and left joints 5, 5 formed at the edges of the end flanges, respectively.

[0039] In the Z-shaped rolled steel sheet pile 1a, the two end flanges 3 are parallel and the entire cross-sectional view is point-symmetric, except for the joint. The right and

left joints are arranged so that two fitting grooves open in the same direction and the cross-section of the two joints are line-symmetric.

[0040] Figures 4(a), 4(b) and 4(c) illustrate examples of a cross-sections of steel sheet pile walls 6 made by a combination of the Z-shaped rolled steel sheet piles 1a to which the joint of the present invention is applied. The Z-shaped rolled steel sheet piles 1a enable the construction of a steel sheet pile wall 6 with various cross-section performance by selecting the way of interlocking adjacent steel sheet piles 1a. For example, Figure 4(a) illustrates a steel sheet pile wall 6 where the steel sheet piles 1a are combined so as to be turned over alternatively, Figure 4(b) illustrates a steel sheet pile wall 6 where a pair of steel sheet piles 1a are interlocked so that the pair is turned over alternatively, and Figure 4(c) illustrates a steel sheet pile wall 6 where all the sheet piles are facing in the same direction to limit the height of the cross-section as much as possible.

[0041] A steel sheet pile wall 6 other than the one illustrated in Figure 4(a) can provide a wall cross-sectional rigidity ranging from 0.2 to 2.5 times that of the wall shown in Figure 4(a).

[0042] Figures 5(a), 5(b) and 5(c) illustrate examples of joints of a rolled steel sheet pile of the present invention. The joint 5 in all examples includes a connecting portion 5a, a bottom portion 5b and an engaging edge portion 5c, which form an approximately trapezoidal and tapered-off fitting groove 5d. A protrusion 5e is formed on the fitting groove side of the connecting portion 5a, which is for preventing the joint from rotation.

[0043] A joint of the steel sheet pile is formed by bending at the terminal stage of the rolling process by using rolls for nipping and applying pressure from the outside to the edge portion of the steel plate, which has been formed by rolling at a previous stage. In view of this, a shorter joint length (summation of the lengths of the connecting portion, the

bottom portion and the engaging edge portion) provides a higher manufacturing productivity. Figure 5(b) illustrates a modified example of a joint in Figure 5(a), where a joint fitting angle, i.e., the direction of the engaging edge portion, is changed to be more vertical for minimizing an amount of steel that must be used in the manufacture of the steel sheet pile. Figure 5(c) illustrates another modified example for reducing the weight and increasing the strength of the joint. The joint of Figure 5(c) has a protrusion 5e instead of one pawl of the background art joint shown in Figure 7(b), which enables rolling accuracy to be less strict.

[0044] The rolled steel sheet pile of the present invention has a pair of right and left joints, one of which is point symmetric or line-symmetric with the other one in cross-section. In other words, the joints 5 on the opposite ends of the rolled steel sheet pile have the same shape in cross-section; however, the joints either open in the same direction or in opposite directions.

[0045] When a plurality of rolled steel sheet piles of the present invention is interlocked, a joint of one sheet pile is interfitted with a joint of an adjacent sheet pile to form a pair of interfitted or interlocked joints, which are point-symmetric in cross-sectional shape. The rolled steel sheet pile of the present invention has a pair of joints, which is arranged so that the center of a point of symmetry of the pair of interfitted joints is positioned on or near the centerline 20 of the end flanges 3 in the thickness direction. This configuration is for minimizing the distance from each part of the joint where a bending moment arm/stress is concentrated to a point of a load vector so as to provide a high strength joint. In addition, the steel sheet pile of the present invention keeps its symmetric shape in the width direction while being rolled until the terminal stage of the rolling process where the joint portion is to be formed by bending. This serves to prevent the occurrence of bending and/or warping of the steel sheet and leads to a very stable manufacturing of the steel sheet pile. The rolled

steel sheet pile of the present invention is interlocked by using joints with the same shaped cross-section, which results in an increase in the degree of freedom of selecting a combination of steel sheet piles. This enables a steel sheet pile wall to be built with various cross-sectional performance, while a conventional steel sheet pile product can provide only one wall cross-sectional performance.

[0046] The rolled steel sheet pile of the present invention has a pair of joints, which are arranged so that the center of the point of symmetry of the pair of interfitted joints is positioned on or near the centerline 20 of the end flange in the thickness direction. The reason why this configuration can minimize the distance from each part of the joint where a bending moment arm/stress is concentrated to a point of a load vector will now be explained with reference to Figures 6(a), 6(b), 6(c) and 6(d). It should be noted that Figures 6(a)-6(d) are only for explanation purposes. Accordingly, other elements of the present invention such as the rotation preventing protrusion formed near the border between the joint portion and the end flange portion are not illustrated.

[0047] Figures 6(a) and 6(b) illustrate joints which have an engaging edge portion with the same cross-sectional shape, but are connected to respective end flanges in different connecting positions. A broken line 20 represents a centerline of the end flange in thickness direction, a point 22 represents a fracture point, i.e., a part of the joint where the stress is concentrated, an arrow 24 identifies a load vector, and L(a) and L(b) identify the distance between the fracture point and the load vector.

[0048] Figure 6(c) illustrates a pair of joints, which are arranged so that the center of a point of symmetry of the pair of interfitted joints is positioned on or near the centerline 20 of the end flange in the thickness direction, according to an embodiment of the present

invention. The distance L_c is the shortest compared to L_a in Figure 6(a), L_b in Figure 6(b) and L_d in Figure 6(d).

[0049] When adjacent steel sheet piles are interlocked to form a pair of interfitted or interlocked joints, parts of each joint are stressed from the force of the adjacent sheet piles being pulled away from each other. In order to increase the strength of the joint against stress, it is recommended to design the joint so as to minimize a moment arm, which can be realized by the configuration where the pair of joints are designed so that the center of the point of symmetry of the pair of interfitted joints is positioned on or near the centerline 20 of the end flange in the thickness direction. Figure 6(c) illustrates the smallest moment arm, and is therefore the preferred design. In this particular arrangement, it should also be noted that the end flanges connected to the pair of interfitted joints are generally co-axial.

[0050] It should be noted that throughout the present specification, rolled steel sheet pile has been discussed. However, the present invention is not limited to rolled steel sheet pile. Other metal sheet pile is also included within the scope of the present invention.

[0051] The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.